Topic: Origins, Acceleration and Evolution of the Solar Wind

Project Title:
Improving Localization of the Source Regions of the Solar Wind

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Project Information:
This proposal aims at better localization of the source regions of the solar wind observed in near-Earth space, by improving full-surface (synoptic) magnetic maps commonly used to compute macroscopic properties of the solar wind. We concentrate on updating the magnetic field in the polar regions. The solar wind is generally divided into two categories, fast and slow. We often associate the fast solar wind with coronal holes, dark regions in EUV and soft X-ray images. In comparison, there is hardly any consensus as to the origin of the slow solar wind. It is of vital importance to reliably locate the source regions in order to test the models of the solar wind. Knowing the source regions will also help us understand various properties of the solar wind, in terms of the properties of the source region. However, without the actual measurement of the solar wind very close to the Sun, we cannot directly locate the source regions. Instead, we have to depend on models that show where on the Sun we are magnetically connected to and thus exposed to the solar wind. These models generally require the radial component of the magnetic field of the full solar surface, i.e. a synoptic magnetic map, as boundary conditions. This is not observationally available.

Presently, the solar magnetic field is measured exclusively from the Earth. Only less than one half of the surface is adequately sampled by these measurements. We may use helioseismic farside imaging combined with STEREO EUV images to detect strong magnetic field regions on the backside. Magnetograms taken several days before or after may tell us whether there were indeed such regions on the backside, assuming that they would survive without drastic changes for several days. However, the polar regions are inherently very hard to observe from the ecliptic, and the historical measurements of magnetic field close to the poles may have large uncertainties. It is possible that these uncertainties may seriously impact our understanding of the magnetic connection between the Sun and Earth. In polar regions, the radial component of the field becomes almost perpendicular to the line of sight, and high-resolution and high-sensitivity vector measurements become essential.

We propose to improve synoptic maps that serve as the lower boundary conditions for models, simple and complex alike, by incorporating measurements of the vector field in the polar regions by the Hinode Spectro-polarimeter (SP) and SDO Helioseismic and Magnetic Imager (HMI). To date, SP is the best resource for the polar field due to its high spatial and spectral resolution. Inversions not included in the pipeline will be explored on SP data to ensure the best results for the polar regions. HMI is needed not only to correct for the SP pointing but also to address the time variability of the polar field. We will calibrate HMI data with SP, and use their radial field for updating the polar regions in the synoptic maps from HMI line-of-sight magneotograms. Using these maps, we run both the potential field source surface (PFSS) model and magnetohydrodynamic (MHD) model to locate the magnetic footpoint of the observer at L1 and estimate the uncertainties of the location. We will systematically conduct this study for periods selected on the basis of the difficulty of locating the source region of the solar wind. The proposed research should be an important part of FST#2, and will form the basis of other projects in the team whose emphasis may be the mechanisms of heating and acceleration of the solar wind.

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Citations: